

CONSULTANTS GROUP

GEOLOGY

ENGINEERING

ENVIRONMENT

HYDROLOGY

May 15, 1991

Mr. Lyle Stott
Engineer
Utah Bureau of Water Pollution Control
288 North 1460 West
Salt Lake City, Utah 84116-0690

RE: Report on Results of Clay Liner Investigation Methods - Tenneco Minerals Company
Goldstrike Mine Barren Solution Pond

Dear Mr. Stott:

On April 18, 1991, JBR Consultants Group and Tenneco Minerals Company personnel conducted an investigation of the clay liner beneath the barren solution pond at the Goldstrike Mine. The methodology and results of this investigation are discussed below.

Methodology

Since the sampling methodology used in the investigation of the release from the leach pad #1 sump area was found to be effective, the general methods of clay liner investigation employed there were also used for the barren pond. A brief review of construction conditions revealed that the pond was constructed entirely on engineered fill material and, that the pre-construction terrain could not be expected to result in any localized differential significant settlement or compaction. In addition, a review of the engineering testing data for the pond foundation revealed that the construction specifications were met. The foregoing factors resulted in the conclusion that there are no definable sites or zones that would result in differential settlement or compaction within the pond foundations. The criteria for sample site selection were determined to be observable liner wetness or moistness and adequate and representative coverage of the entire surface area of the pond bottom.

The sites chosen for sampling are shown on the attached location map. Sites #1 through #5 were clustered near the southwest corner of the pond in the vicinity of the leak detection sump and where the greatest hydraulic head would have developed in the leak detection system. The remaining samples were arrayed across the pond bottom to assess

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moisture impacts up-slope from the sump. Evidence of wetness or excessive moisture in the clay liner was detected by carefully walking over the pond bottom. As was learned during the leach pad #1 investigation, wetness in clay beneath FML is readily noted underfoot. Detectable wetness was concentrated in the vicinity of the sump. The eleven sample sites provide a sufficient number of samples to adequately assess the presence of contaminants in the clay liner which could have resulted from leakage of cyanide solutions through the FML. The sampling is not meant to be representative of the overall clay liner since it was purposely skewed toward areas of most probable contamination as evidenced by wetness.

At each sample site a 4 to 5 inch square of FML, geogrid, and geofabric was cut away to expose the clay liner. Sampling was accomplished using a soil auger. In general, samples were taken continuously beginning with the 0-3" interval, then the 3-6" interval, and continuing at approximately 6-inch intervals. Augers were thoroughly cleaned between samples. Each bore hole was advanced until auger refusal was reached. Hole depths ranged from 12 to 22 inches. Boreholes were plugged with bentonite. Samples were placed in wide-mouthed plastic bottles, cooled, and submitted for laboratory analysis for total and WAD cyanide, Au, Ag, and Zn. The three metals were chosen because they may be expected to be present in the recycled leach solutions and are less likely to be found in naturally high concentrations in the clay, as would be the case with many other metals.

Results

The results of the chemical analyses for the eleven samples are shown on the accompanying laboratory analytical reports and are summarized on the attached table. Inspection of the table demonstrates that cyanide, either as total or weak acid dissociable (WAD), is with two possible exceptions (BP 1, 6-9" and BP 6, 3-10"), encountered only in the upper six inches at each sample location. The samples from the upper interval of each bore hole encountered measurable concentrations of WAD and total cyanide. The maximum total cyanide concentration in any sample is 4.4 ppm. The maximum WAD cyanide concentration in any sample is 0.85 ppm.

Gold was undetectable in all samples. Silver was encountered only in one sample, the upper 3 inches of sample BP 6. The reasons for no detection of precious metals values in most samples is probably the result both of low concentrations in the barren solution and the attenuation of these metals by the clay near the points of release through the flexible membrane liner.

Results of zinc analyses show a general trend toward decreased zinc concentrations with depth in most bore holes. However, the changes in concentration are relatively subtle and are undoubtedly due in part to natural variations in the zinc content of the clay. The mean concentration of zinc in all of the samples taken is 37.7 ppm. This is very close to the mean zinc concentration found in clay horizons of soils in the vicinity of the pond sites. Results of a soil sampling program in the area yielded a mean concentration of zinc of approximately 41.7 ppm. Given the low concentrations of zinc in the liner samples and the similarity to natural concentrations of zinc in the clays in the area, it is not certain whether or not the observed decreases in zinc concentration with depth in the clay liner are real or

coincidental. The overall trend does, however, suggest that zinc from the barren solution may have been attenuated by the clays in the upper one third of the liner.

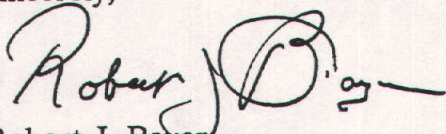
In addition to the chemical analyses, observation of moisture in samples during sampling indicated that only the upper 3 to 6 inches of clay in each boring appeared to be excessively moist due to wetting from the barren solution leakage. The lower samples from each boring displayed relatively low moisture contents as would be expected based upon the compaction specification for the liner.

Conclusions

The results of this investigation indicate that the impacts from the release of cyanide solution from the primary liner system of the barren solution pond were confined virtually to the upper 6 inches of the clay liner. Therefore, up to 6 inches is the maximum depth of contamination in most borings. The results of the entire suite of chemical analyses indicate that the impact of the solution release was confined entirely within the upper one third of the clay liner system. This investigation yielded no evidence of any release of cyanide solutions to the environment from the barren solution pond; consequently, it is our opinion that corrective action for the clay liner is not warranted.

Please feel free to contact me should you or others in the Bureau have any questions regarding this investigation or its results.

Sincerely,

A handwritten signature in black ink, appearing to read "Robert J. Bayer", followed by a horizontal line.

Robert J. Bayer
Vice President

cc: K. Kluksdahl, Tenneco Minerals Company
D. Brannum, Tenneco Minerals Company

Tenneco Goldstrike Mine
Results for Barren Pond, Clay Liner Samples

Sample	Depth (in.)	North* (ft)	East* (ft)	Total Cyanide (mg/Kg)	WAD Cyanide (mg/Kg)	Total Au (mg/Kg)	Total Ag (mg/Kg)	Total Zn (mg/Kg)
BP-1	0-6	7.5	1	0.87	0.85	<0.1	<0.1	52.1
BP-1	6-9	"	"	0.82	<0.2	<0.1	<0.1	37.7
BP-1	9-12	"	"	<0.2	<0.2	<0.1	<0.1	41.4
BP-2	0-3	8.0	1.5	1.6	<0.2	<0.1	<0.1	49.4
BP-2	3-6	"	"	0.33	<0.2	<0.1	<0.1	42.2
BP-2	6-9	"	"	<0.2	<0.2	<0.1	<0.1	38.2
BP-3	0-3	3.0	16.5	2.7	1.0	<0.1	<0.1	46.8
BP-3	3-6	"	"	0.34	<0.2	<0.1	<0.1	47.5
BP-3	6-9	"	"	<0.2	<0.2	<0.1	<0.1	15.3
BP-4	0-3	13	11	2.8	0.4	<0.1	<0.1	35.5
BP-4	3-6	"	"	0.55	<0.2	<0.1	<0.1	55.7
BP-4	6-12	"	"	<0.2	<0.2	<0.1	<0.1	42.3
BP-4	12-14	"	"	<0.2	<0.2	<0.1	<0.1	30.8
BP-5	0-3	21.5	3.5	1.4	0.52	<0.1	<0.1	43.8
BP-5	3-6	"	"	2.4	<0.2	<0.1	<0.1	39.8
BP-5	6-13	"	"	<0.2	<0.2	<0.1	<0.1	25.3
BP-6	0-3	41.5	4.5	3.8	1.0	<0.1	0.14	33.2
BP-6	3-10	"	"	1.8	0.53	<0.1	<0.1	56.7
BP-6	10-16	"	"	<0.2	<0.2	<0.1	<0.1	32.2
BP-6	16-18	"	"	<0.2	<0.2	<0.1	<0.1	26.0
BP-7	0-3	29.5	30.0	4.4	0.33	<0.1	<0.1	43.0
BP-7	3-6	"	"	1.9	<0.2	<0.1	<0.1	40.6
BP-7	6-12	"	"	<0.2	<0.2	<0.1	<0.1	36.5
BP-7	12-16	"	"	<0.2	<0.2	<0.1	<0.1	28.4
BP-7	16-22	"	"	<0.2	<0.2	<0.1	<0.1	16.4
BP-7	22-25	"	"	<0.2	<0.2	<0.1	<0.1	26.4
BP-8	0-3	7.5	48	3.7	0.4	<0.1	<0.1	49.5
BP-8	3-6	"	"	1.9	<0.2	<0.1	<0.1	40.8
BP-8	6-12	"	"	<0.2	<0.2	<0.1	<0.1	36.1
BP-8	12-15	"	"	<0.2	<0.2	<0.1	<0.1	30.5
BP-9	0-3	29.5	52	3.1	<0.2	<0.1	<0.1	31.7
BP-9	3-6	"	"	<0.2	<0.2	<0.1	<0.1	39.6
BP-9	6-12	"	"	<0.2	<0.2	<0.1	<0.1	34.6
BP-10	0-3	50	33	3.5	3.0	<0.1	<0.1	58.9
BP-10	3-6	"	"	0.6	0.4	<0.1	<0.1	21.6
BP-10	6-12	"	"	<0.2	<0.2	<0.1	<0.1	35.4
BP-10	12-15	"	"	<0.2	<0.2	<0.1	<0.1	37.4
BP-11	0-3	50	65.5	3.1	2.6	<0.1	<0.1	38.4
BP-11	3-6	"	"	0.29	<0.2	<0.1	<0.1	37.0
BP-11	6-12	"	"	<0.2	<0.2	<0.1	<0.1	31.9

* Distance from bottom southwest corner of pond.

BOTTOM OF POND

•BP-11

•BP-10

•BP-6

•BP-7

•BP-9

•BP-5

•BP-4

•BP-8

•BP-2
•BP-1

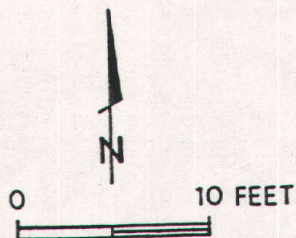
•BP-3



LID
SUMP

EXPLANATION

•BP-3 SAMPLE LOCATION AND
SAMPLE NUMBER



**TENNECO MINERALS
COMPANY**

SAMPLE LOCATION MAP



CONSULTANTS GROUP
SALT LAKE CITY, UTAH

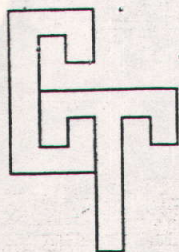
5/14/91

TO: JBR Consultants
1952 E. Fort Union Blvd. Ste 209
Salt Lake City, Utah 84121

CERTIFICATE OF ANALYSIS

SAMPLE ID:	BP-1 0-6" <u>U062523</u>	BP-1 6-9" <u>U062524</u>	BP-1 9-12" <u>U062525</u>	BP-2 0-3" <u>U062526</u>
<u>PARAMETER</u>				
Cyanide as CN-T, mg/Kg	0.87	0.82	<.2	1.6
WAD Cyanide as CN, mg/kg	<.1	<.1	<.2	<.2
Gold as Au (T), mg/Kg	<.1	<.1	<.1	<.1
Silver as Ag (T), mg/Kg	<.1	<.1	<.1	<.1
Zinc as Zn (T), mg/Kg	52.1	37.7	41.4	49.4


Rex Henderson



CHEMTECH

ANALYTICAL LABORATORY

6100 S. STRATLER
MURRAY, UTAH 84107
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DATE: 5-07-91

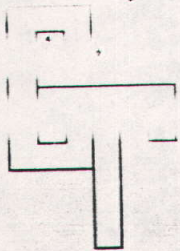
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DATE SUBMITTED: 4-19-91 - Tenneco Barren Pond Liner

CERTIFICATE OF ANALYSIS

SAMPLE ID:	BP-2 3-6"	BP-2 6-9"	BP-3 0-3"	BP-3 3-6"
LAB #:	<u>U062527</u>	<u>U062528</u>	<u>U062529</u>	<u>U062530</u>
<u>PARAMETER</u>				
Cyanide as CN-T, mg/Kg	0.33	<.2	2.7	0.34
WAD Cyanide as CN, mg/Kg	<.2	<.2	1.0	<.2
Gold as Au (T), mg/Kg	<.1	<.1	<.1	<.1
Silver as Ag (T), mg/Kg	<.1	<.1	<.1	<.1
Zinc as Zn (T), mg/Kg	42.2	38.2	46.8	47.5


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CERTIFICATE OF ANALYSIS

SAMPLE ID:	BP-3	BP-4	BP-4	BP-4
	6-9"	0-3"	3-6"	6-12"
LAB #:	<u>U062531</u>	<u>U062532</u>	<u>U062533</u>	<u>U062534</u>
<u>PARAMETER</u>				
Cyanide as CN-T, mg/Kg	<.2	2.8	0.55	<.2
WAD Cyanide as CN, mg/Kg	<.2	0.4	<.2	<.2
Silver as Ag (T), mg/Kg	<.1	<.1	<.1	<.1
Zinc as Zn (T), mg/Kg	15.3	35.5	35.7	42.0


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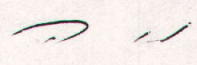
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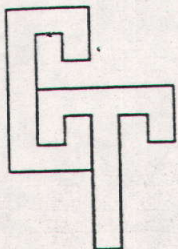
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CERTIFICATE OF ANALYSIS

SAMPLE ID:	BP-4 12-14" <u>U062535</u>	BP-5 0-3" <u>U062536</u>	BP-5 3-6" <u>U062537</u>	BP-5 6-13" <u>U062538</u>
LAB #:				
<u>PARAMETER</u>				
Cyanide as CN-T, mg/Kg	<.2	1.4	2.4	<.2
WAD Cyanide as CN, mg/Kg	<.2	0.52	<.2	<.2
Gold as Au (T), mg/Kg	<.1	<.1	<.1	<.1
Silver as Ag (T), mg/kg	<.1	<.1	<.1	<.1
Zinc as Zn (T), mg/Kg	30.8	43.8	39.3	25.3


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SAMPLE ID:	BP-6 0-3"	BP-6 3-10"	BP-6 10-16"	BP-6 16-18"
LAB #:	<u>U062539</u>	<u>U062540</u>	<u>U062541</u>	<u>U062542</u>
<u>PARAMETER</u>				
Cyanide as CN-T, mg/Kg	3.8	1.8	<.2	<.2
WAD Cyanide as CN, mg/Kg	1.0	0.53	<.2	<.2
Gold as Au (T), mg/Kg	<.1	<.1	<.1	<.1
Silver as Ag (T), mg/Kg	0.14	<.1	<.1	<.1
Zinc as Zn (T), mg/Kg	33.2	56.7	32.2	26.0


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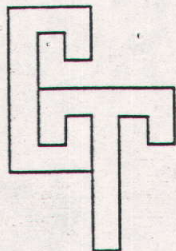
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CERTIFICATE OF ANALYSIS

SAMPLE ID:	BP-7 0-3"	BP-7 3-6"	BP-7 6-12"	BP-7 12-16"
LAD #:	<u>0002070</u>	<u>0002071</u>	<u>0002072</u>	<u>0002073</u>
PARAMETER				
Cyanide as CN-T, mg/Kg	4.4	1.9	<.2	<.2
Urb. Cyanide as CN, mg/Kg	0.33	<.2	<.2	<.2
Gold as Au (T), mg/Kg	<.1	<.1	<.1	<.1
Silver as Ag (T), mg/Kg	<.1	<.1	<.1	<.1
Zinc as Zn (T), mg/Kg	43.0	40.6	36.5	28.4


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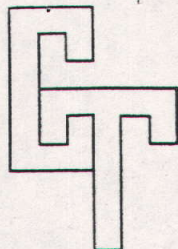
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SAMPLE ID:	BP-7	BP-7	BP-8	BP-8
	16-22"	22-25"	0-3"	3-6"
LAB #:	<u>U062547</u>	<u>U062548</u>	<u>U062549</u>	<u>U062550</u>
<u>PARAMETER</u>				
Cyanide as CN-T, mg/Kg	<.2	<.2	3.7	1.9
WAD Cyanide as CN, mg/Kg	<.2	<.2	0.40	<.2
Gold as Au (T), mg/Kg	<.1	<.1	<.1	<.1
Silver as Ag (T), mg/Kg	<.1	<.1	<.1	<.1
Zinc as Zn (T), mg/Kg	16.4	26.4	49.5	40.8


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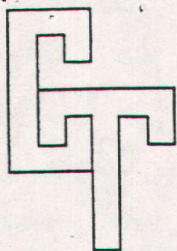
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Salt Lake City, Utah 84121

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CERTIFICATE OF ANALYSIS

SAMPLE ID:	BP-8 6-12"	BP-8 12-15"	BP-9 0-3"	BP-9 3-6"
LAB #:	<u>U062551</u>	<u>U062552</u>	<u>U062553</u>	<u>U062554</u>
<u>PARAMETER</u>				
Cyanide as CN-T, mg/Kg	<.2	<.2	3.1	<.2
WAD Cyanide as CN, mg/Kg	<.2	<.2	<.2	<.2
Gold as Au (T), mg/Kg	<.1	<.1	<.1	<.1
Silver as Ag (T), mg/Kg	<.1	<.1	<.1	<.1
Zinc as Zn (T), mg/Kg	36.1	30.5	31.7	39.6


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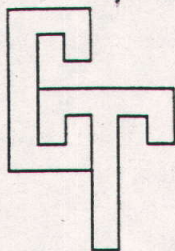
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SAMPLE ID:	BP-9 6-12"	BP-10 0-3"	BP-10 3-6"	BP-10 6-12"
LAB #:	<u>U062555</u>	<u>U062556</u>	<u>U062557</u>	<u>U062558</u>
<u>PARAMETER</u>				
Cyanide as CN-T, mg/Kg	<.2	3.5	0.60	<.2
WAD Cyanide as CN, mg/Kg	<.2	3.0	0.4	<.2
Gold as Au (T), mg/Kg	<.1	<.1	<.1	<.1
Silver as Ag (T), mg/Kg	<.1	<.1	<.1	<.1
Zinc as Zn (T), mg/Kg	34.6	58.9	21.6	35.4


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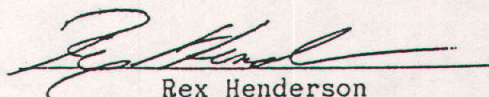
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SAMPLE ID:	BP-10 12-15"	BP-11 0-3"	BP-11 3-6"	BP-11 6-12"
LAB #:	<u>U062559</u>	<u>U062560</u>	<u>U062561</u>	<u>U062562</u>
<u>PARAMETER</u>				
Cyanide as CN-T, mg/Kg	<.2	3.1	0.29	<.2
WAD Cyanide as CN, mg/Kg	<.2	2.6	<.2	<.2
Gold as Au (T), mg/Kg	<.1	<.1	<.1	<.1
Silver as Ag (T), mg/Kg	<.1	<.1	<.1	<.1
Zinc as Zn (T), mg/Kg	37.4	38.4	37.0	31.9


Rex Henderson